CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM (CERES)

VALIDATION PLAN

MONTHLY REGIONAL TOA AND SURFACE RADIATION BUDGET (SUBSYSTEM 10.0)

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CERES VALIDATION PLAN

10.0 MONTHLY REGIONAL TOA AND SURFACE RADIATION BUDGET

10.1 INTRODUCTION

10.1.1 Measurement and science objectives

The science objective of the CERES (Wielicki et al., 1996, 1998) monthly mean top-of-atmosphere (TOA) and surface radiation budget (SRB) averages data product is to accomplish the dual goals of providing a stable, long-term monthly mean data set of shortwave (SW) and longwave (LW) radiative parameters at the TOA and surface using a data processing system consistent with the Earth Radiation Budget Experiment (ERBE; Barkstrom 1984) and, at the same time, producing the most accurate monthly mean data set currently available based on state-of-the-art techniques. To accomplish these goals, CERES will produce regional, zonal, and global means by both the ERBE-like technique and the geostationary-enhancement method (Young et al., 1998).

10.1.2 Missions

The CERES instruments will be flown on multiple satellites, which include TRMM, Terra, and Aqua, to provide the diurnal sampling necessary to obtain accurate monthly averages of the TOA radiative parameters.

10.1.3 Science data products

The CERES TISA data algorithm for Subsystem 10 produces the monthly TOA and SRB average data product (SRBAVG) which contains monthly and monthly-hourly regional, zonal, and global averages of the TOA and surface LW and SW fluxes and the observed cloud conditions for each CERES 1-degree equal-angle region. This product differs from the AVG product in Subsystem 8 in three ways. First, the surface fluxes are calculated from the TOA fluxes using TOA-to-surface parameterization, instead of using the radiative transfer models provided by the SARB subsystem. Second, no flux fields are calculated at levels between the TOA and surface. Lastly, the regional fluxes are calculated using both the ERBE-like method and the geostationary data enhancement technique. There is an SRBAVG product for each spacecraft and for each combination of spacecraft. There are 69 data parameters in each of the SRBAVG data products. These include mean estimates of SW and LW radiant flux at the TOA and at the surface from both of the methods, column-averaged cloud properties, the standard deviations of these estimates, location and scene types. A complete list of data parameters is in the CERES Data Products Catalog (http://asd-www.larc.nasa.gov/DPC/DPC.html).

In the next section, we will discuss the method adopted by the CERES Time Interpolation and

Spatial Averaging (TISA) working group for validating the SRBAVG data product. Section 10.3 and 10.4 outline both pre-launch and post-launch validation studies. Section 10.5 provides details on implementing validation results in data production. A summary is given in Section 10.6.

10.2 VALIDATION CRITERION

10.2.1 Overall approach

The science algorithms for TOA parameters are based on the ERBE-like technique (Subsystem 3) and the new CERES geostationary-enhancement method (Subsystem 7). A few minor differences do exist. For example, the input data for this subsystem are derived from the SFC data product instead of the FSW. In addition, the data are sorted in terms of local time, not GMT. The first step in the averaging algorithms is to sort the FSW data in space and local time. The sorting of the gridded geostationary data is then done in a similar manner. Column-averaged cloud data are time interpolated to all local times using a linear technique. The complete time series of column-averaged data is used to compute monthly and monthly-hourly means. Monthly means of the Angular Model Scene Class data are computed using only data from the times of CERES observations. The temporal interpolation of total-sky LW and SW fluxes is identical to the technique described in Subsystem 3 (ERBE-like technique) and Subsystem 7 (new CERES geostationary-enhancement method). However, estimates of daily regional SW flux from the new CERES method are made only for days with at least one CERES observation. Only these days will be used in the calculation of new CERES geostationary enhanced monthly mean fluxes. Time interpolation of clear-sky LW and SW flux are done using ERBE-like method only. No attempt is made to produce clear-sky flux estimates at every hour. Only days with at least one clear-sky flux measurement are modeled and used in the computation of monthly means. Surface SW and LW fluxes are calculated based on TOA-to-surface parameterization schemes given in Subsystem 4.6 (CERES surface radiation budget technique) for every hour in which a TOA flux is calculated. Monthly, monthly-hourly, and daily means are computed in the same manner as used for TOA flux. Once regional means are computed for all parameters and all CERES 1-degree equal-angle gridded regions, these means are combined into zonal and global means using weighting factors to correct for variations in grid box size with latitude. There are three input data sets to this subsystem. They include hourly gridded single satellite CERES TOA and surface fluxes data set (SFC), atmospheric structure data set (ASTR), and gridded geostationary narrowband radiances data set (GGEO). The output of the data processing system produces the monthly TOA and SRB averages data set (SRBAVG).

The overall approach to validating the SRBAVG data product follows very closely to the method outlined in the validation plan for the ERBE-like data product (Subsystem 3) and will not be repeated here. Readers are referred to Subsystem 3 for more details.

In order to conserve resources, the CERES TISA working group will not validate every data parameter listed in the SRBAVG science products. The data parameters used here for validation purposes are 1) LW and SW TOA all-sky flux, 2) LW and SW TOA clear-sky flux, 3) LW and SW surface all-sky flux, 4) LW and SW surface clear-sky flux, and 5) column-averaged cloud properties.

This data product offers the best opportunity for comparisons of monthly means calculated using the ERBE-like temporal interpolation technique and the geostationary-enhanced technique since both methods will be used with identical temporal sampling and spatial gridding resolution. Regional monthly means will be compared directly using the two monthly products created by this subsystem. Time series plots, zonal, and global averages of TOA fluxes and scene identification will also be compared with previously validated ERBE-like products using the tropical mean technique described in the validation plan for Subsystem 3.0. Scatter plots comparing 1.0 degree regions with corresponding 2.5 degree ERBE-like regions will also be used to study the effects of the diminished temporal sampling of the 1.0 degree product.

Monthly mean surface fluxes will be compared with monthly mean fluxes determined from surface observations at NASA/LaRC Chesapeake Lighthouse, Boulder Tower, BSRN (Baseline Surface Radiation Networks), CAVE (CERES/ARM Validation Experiment), and other ARM (Atmospheric Radiation Measurement) sites. The Subsystem 10.0 algorithm assumes that surface fluxes can be calculated for each hour of the month using temporally interpolated TOA fluxes. The surface sites will provide hourly observations of surface fluxes that will also allow determination of instantaneous interpolation errors of surface flux due to this assumption. For global assessments of errors in surface fluxes, comparisons will also be made with results of the GEWEX/SRB project.

This product also includes column-averaged cloud properties. Several different weighting schemes are used to conserve radiative properties such as TOA or surface downwellig LW flux. These weighting schemes will be tested using the CAGEX data set (Charlock and Alberta, 1996). If successful, these column clouds should produce mean cloud conditions consistent with the quantity being conserved.

The geostationary-enhanced interpolation products will also be compared with two new satellite data products, if available. The combination of the European Geostationary Earth Radiation Budget (GERB) radiative fluxes and cloud properties derived from the SEVIRI instrument on the METEOSAT Second Generation Satellite will provide an excellent, high temporal resolution data set. Cloud properties from SEVIRI would be of greatest value if derived with an algorithm that is consistent with CERES and can therefore be directly compared with the CERES interpolated values. Monthly mean fluxes will also be compared with the GERB averages. An additional validation data set will be from the Triana mission. The Triana hemispherical albedos and LW fluxes will provide a comparison of the globally integrated CERES fluxes. Cloud properties from Triana can also be compared with the interpoalted cloud properties from the geostationary data.

10.2.2 Sampling requirements

In order to validate SRBAVG data product, we will require a minimum of six months of data from each of the CERES satellites. Validation priority will be for 1) the first month of data; 2) 4 seasonal months (January, April, July, October); 3) the first full year of data. Additional data months are also required to perform data consistency tests between different satellites (i.e., TRMM against Terra, TRMM against Aqua, and Terra against Aqua).

10.2.3 Measures of success

Accuracy goals for the monthly mean surface and TOA radiative parameters are based closely to those described in Subsystem 3 (ERBE-like method), 4.6 (surface radiation budget), and 7 (geostationary-enhancement technique) and will not be repeated here. Readers are referred to the validation plan of those subsystems for more details.

10.3 PRE-LAUNCH ALGORITHM TEST/DEVELOPMENT ACTIVITIES

Pre-launch data for validating the TOA fluxes are outlined in Subsystem 3 (ERBE-like method), 4.6 (surface radiation budget) and 7 (geostationary-enhancement technique) and will not be repeated.

10.4 POST-LAUNCH ACTIVITIES

The post-launch validation of this subsystem is similar to those given in Subsystem 3 (ERBE-like method), 4.6 (surface radiation budget) and 7 (geostationary-enhancement technique) and will not be repeated. Readers are referred to those subsystems for further details. A schedule of post-launch validation studies that will be performed for the SRBAVG products is given in Table 1 below.

Table 1: CERES Monthly Mean Surface/TOA Validation Schedule

Year	**1998**				**1999**				**2000**				**2001**				**2002**			
Quarter	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Validate GGEO code						x														
Define GGEO monthly errors							x													
Validate Column Cloud code							x													
Validate Column Clouds									x											
TRMM GGEO vs. ERBE-like (1.0)								x												
TRMM GGEO vs. ERBE-like (2.5)								x												

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Quarter	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
TRMM Surface Monthly vs. Surface data											x									
TRMM Instantaneous Surface vs. Surface data												x								
GGEO calibration						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Validate GGEO cloud code										x										
GGEO vs. VIRS clouds												x								
Terra GGEO vs. ERBE-like (1.0)												x								
Terra GGEO vs. ERBE-like (2.5)												x								
Terra Surface Monthly vs. Surface data															x					
Terra Instantaneous Surface vs. Surface data																x				
Aqua GGEO vs. ERBE-like (1.0)																			x	
Aqua GGEO vs. ERBE-like (2.5)																			x	
Aqua Surface Monthly vs. Surface data																				x
Aqua Instantaneous Surface vs. Surface data																				x
Multiple vs. single satellites																				x

10.5 IMPLEMENTATION OF VALIDATION RESULTS IN DATA PRODUCTION

The implementation of TISA validation results is given in Subsystem 7 and will not be repeated. Readers are referred to that subsystem for further details

10.6 SUMMARY

This document describes a plan for validating the CERES SRBAVG data product. This plan is based on validation methods and procedures outlined in Subsystem 3, 4.6, and 7. Readers are referred to those subsystems for further details.

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